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Strueh

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(54) **VANE PUMP HAVING A PRESSURE COMPENSATING VALVE**

(75) Inventor: **Timothy Carl Strueh**, Linden, IN (US)

(73) Assignee: **TRW Automotive U.S. LLC**, Livonia, MI (US)

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F04C 2/344 (2006.01)

(52) **U.S. Cl.** **418/82**; 418/268

(58) **Field of Classification Search** 418/82, 418/268

See application file for complete search history.

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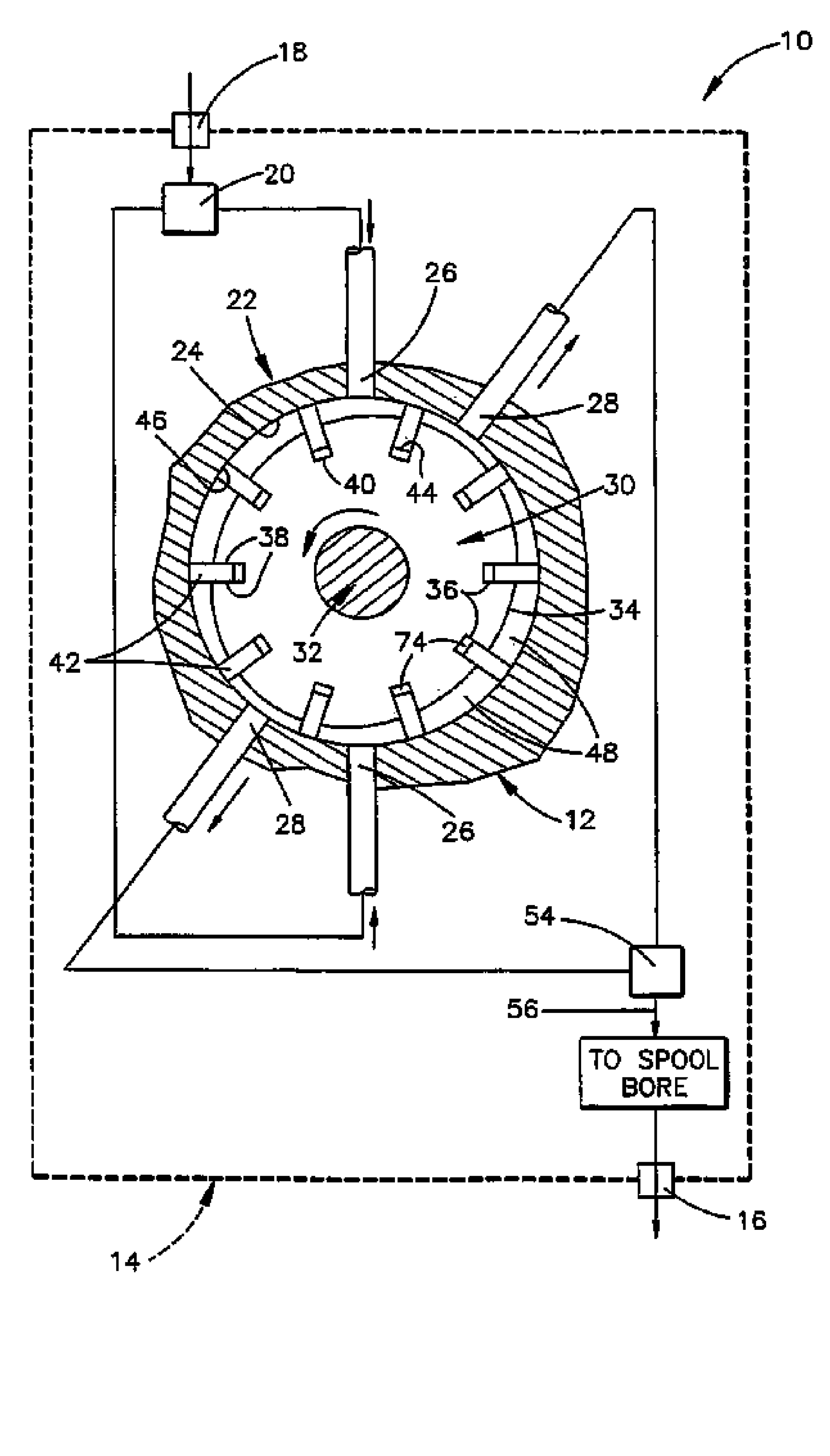
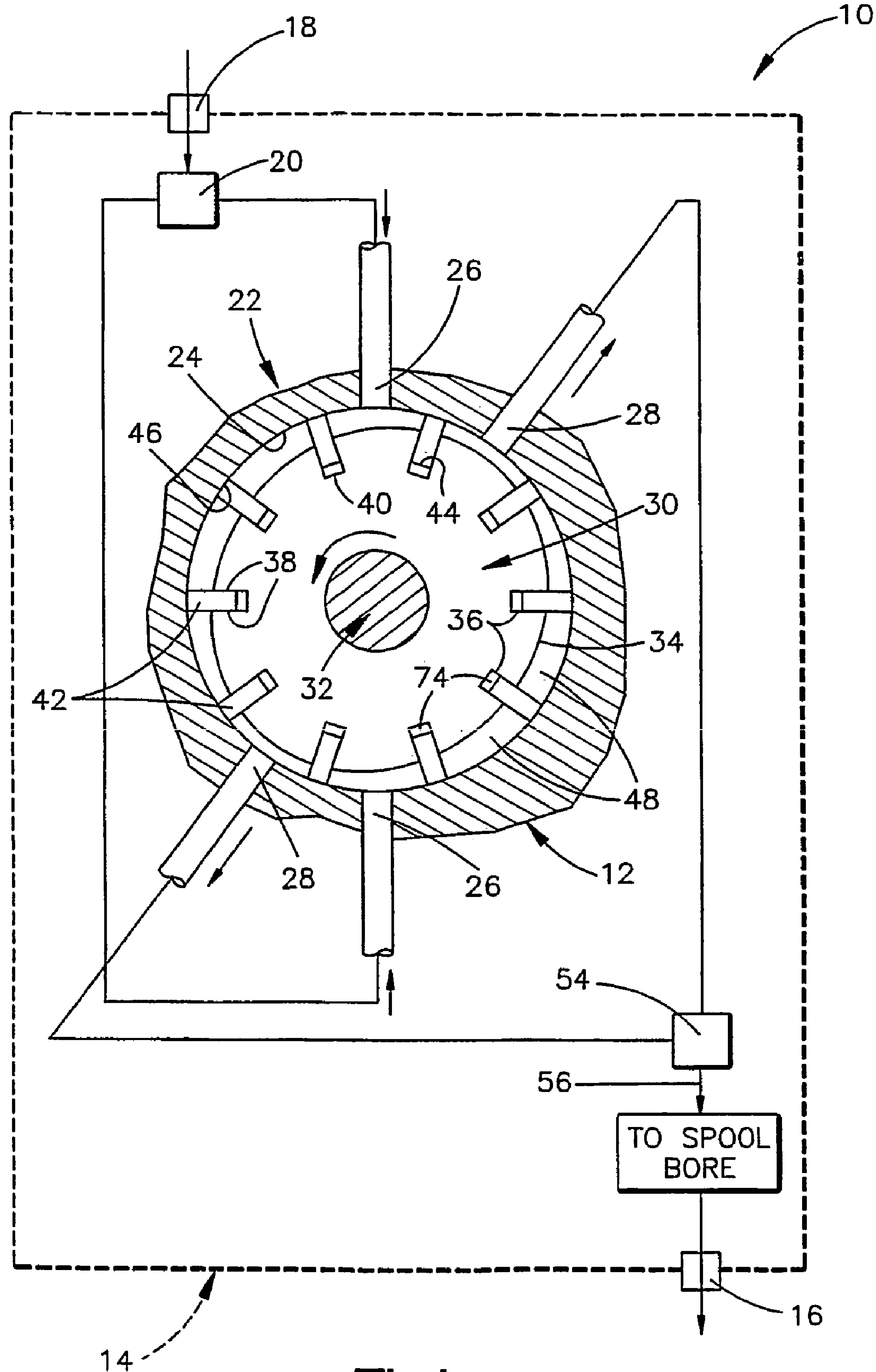
Primary Examiner—Michael Koczo, Jr.
(74) *Attorney, Agent, or Firm*—Tarolli, Sundheim, Covell & Tummino LLP

(57) **ABSTRACT**

An apparatus (**10**) comprises a pump (**12**) and a pressure compensating valve (**94**). The pump (**12**) includes a member (**22**) having a surface (**24**) defining a pumping chamber. A rotatable rotor (**30**) is located in the pumping chamber. The rotor (**30**) has circumferentially spaced vane-like members (**42**) defining pumping pockets (**48**) that expand and contract during rotation of the rotor (**30**). The pump (**12**) has a fluid circuit (**72**) providing fluid pressure for biasing the vane-like members (**42**) of the rotor (**30**) radially toward the surface (**24**). The pressure compensating valve (**94**) controls fluid flow through an outlet (**16**) and also controls the pressure in the fluid circuit (**72**). The pressure compensating valve (**94**) has an initial condition blocking fluid flow through the outlet (**16**) at pump start-up to provide fluid pressure in the fluid circuit (**72**) to bias the vane-like members (**42**) of the rotor (**30**) radially toward the surface (**24**).

11 Claims, 4 Drawing Sheets

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TO SPOOL BORE
16
14

Fig.1

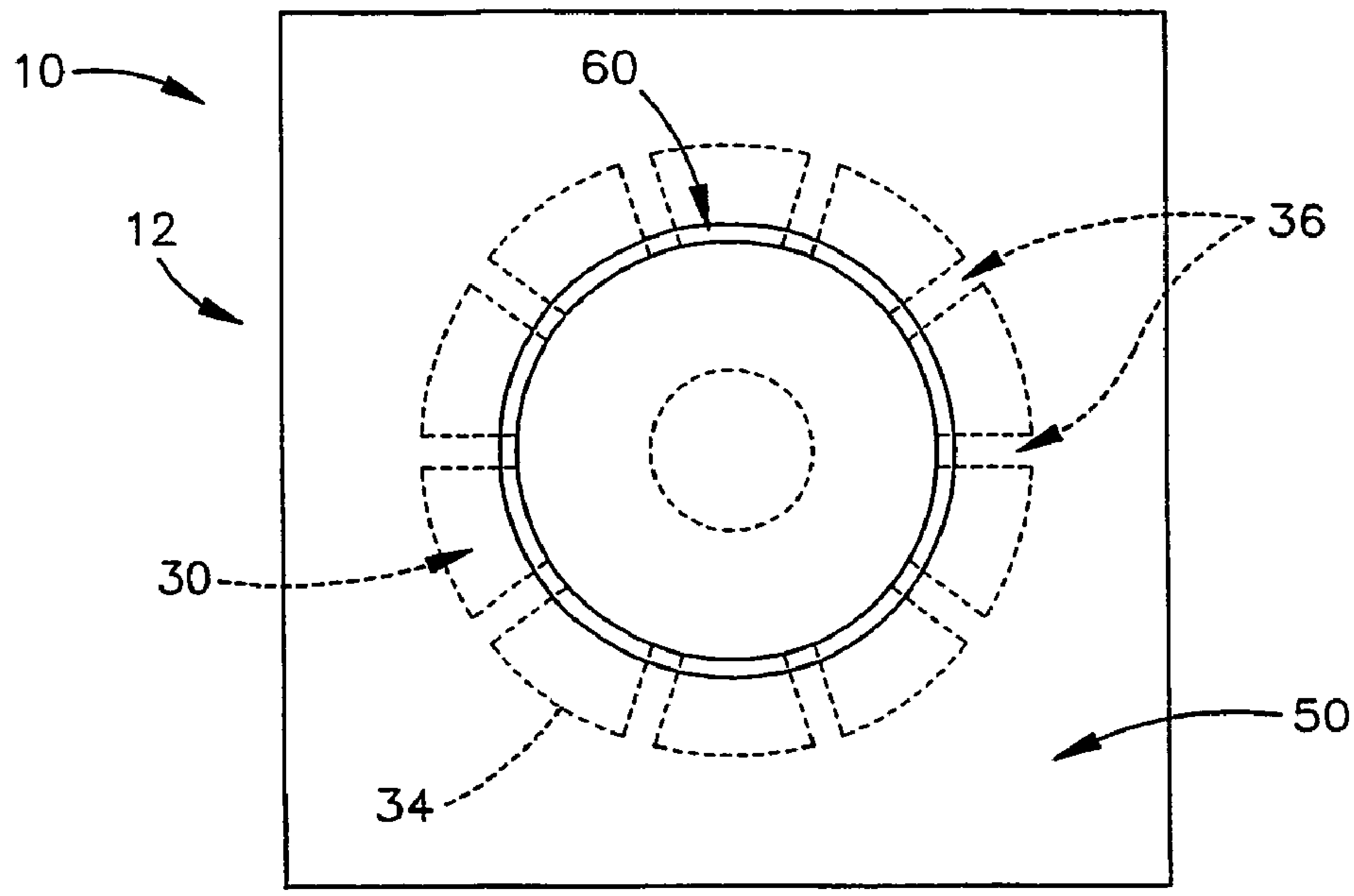
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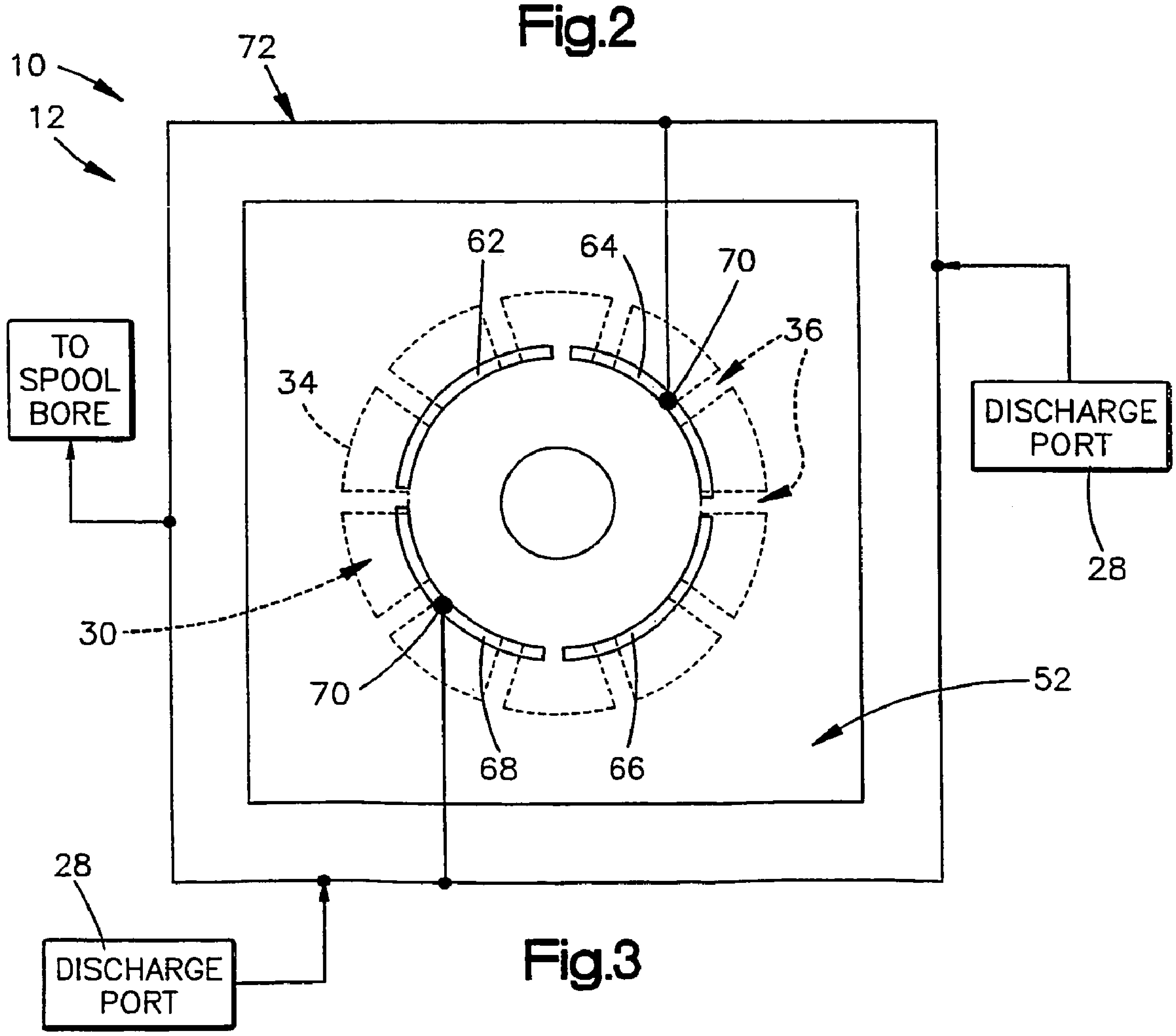
Fig.2


10
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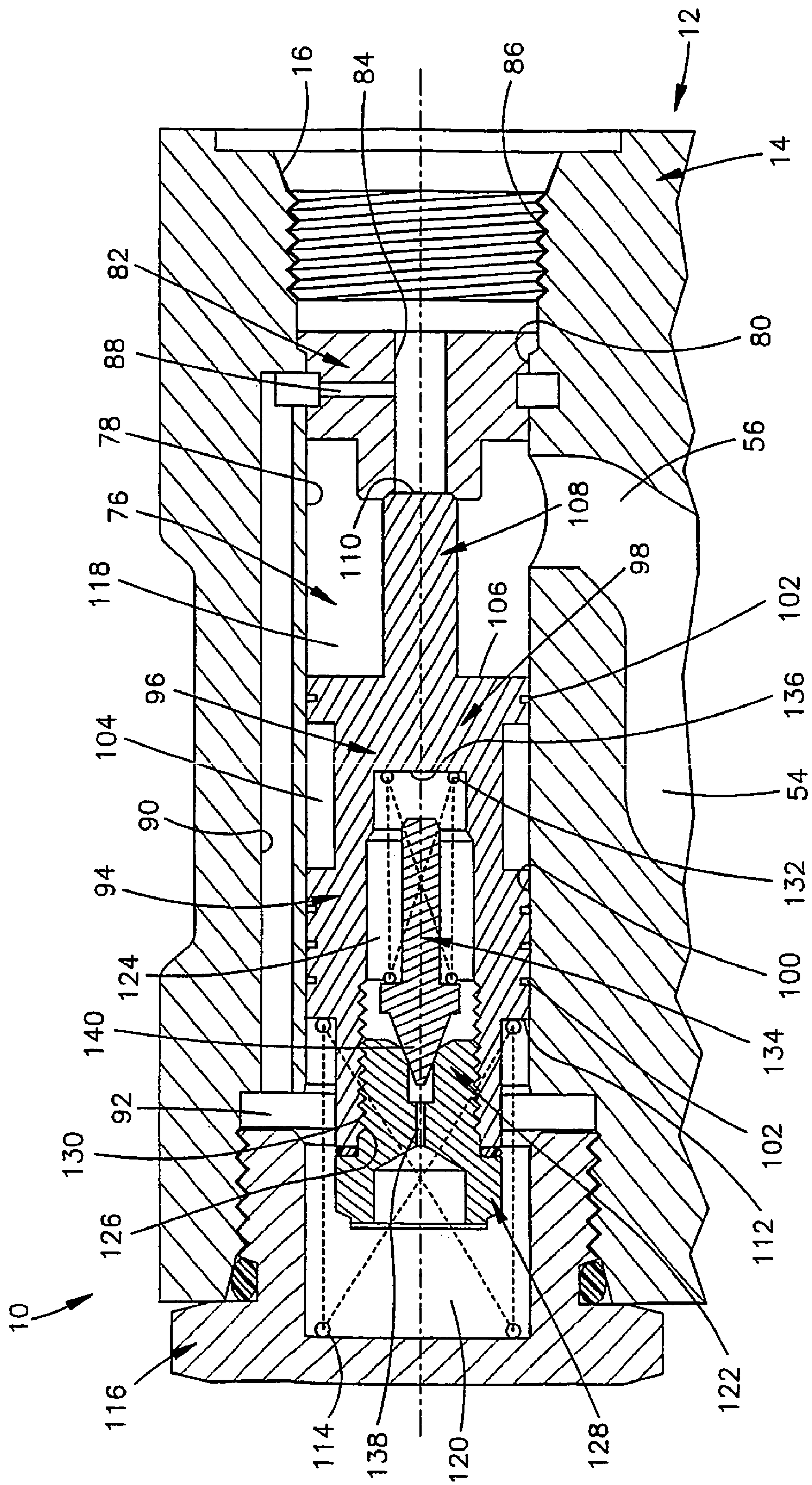
DISCHARGE PORT

Fig.3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128

Fig.4

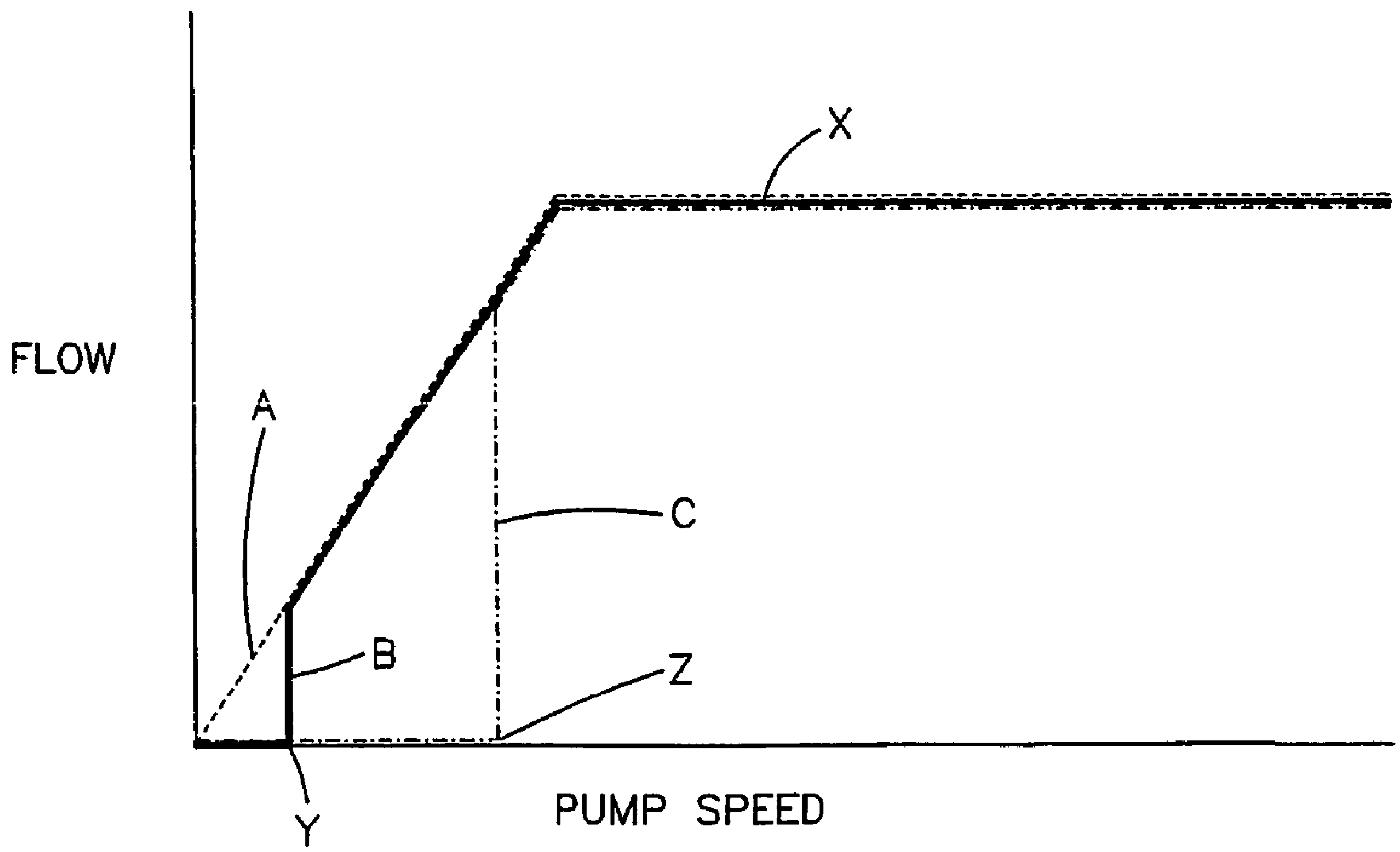

Fig.5

VANE PUMP HAVING A PRESSURE COMPENSATING VALVE

TECHNICAL FIELD

The present invention relates to a pressure compensating valve for a pump. More particularly, the present invention relates to a pressure compensating valve for a pump for supplying steering fluid to a power steering mechanism of a vehicle.

BACKGROUND OF THE INVENTION

Vane pumps are used for supplying fluid to a hydraulic motor of a power steering mechanism. The vane pump includes a rotor that is rotatable within a cam ring. The rotor of the pump includes a plurality of circumferentially spaced grooves. A vane is carried in each groove. The vanes extend radially outwardly from the grooves of the rotor toward a surface of the cam ring. Pumping pockets are formed between adjacent vanes. The pumping pockets receive fluid from an inlet port and deliver fluid to a discharge port of the pump.

When the pump is at rest, i.e., the rotor is stationary relative to the cam ring, the vanes may move radially inwardly into the grooves of the rotor and away from the surface of the cam ring. When the rotor begins to rotate and one or more of the vanes of the pump are in a radially inward position, the amount of fluid discharged from the pump is low relative to pump operation with all of the vanes extended radially outwardly toward the surface of the cam ring.

A hydraulic power steering mechanism requires a minimum flow rate of fluid from the pump for proper operation. When the flow rate is below the minimum value, the power steering mechanism may be non-responsive to inputs requesting power steering assistance.

A vane pump generally cannot provide a fluid flow sufficient to reach the minimum flow rate until all of the vanes of the pump move radially outwardly toward the cam ring surface. Thus, the power steering mechanism may be not sufficiently responsive from pump start-up until all of the vanes are positioned radially outward toward the cam surface.

Upon start-up of the vehicle, the vane pump is rotated from a rest position to an angular velocity that is equal to the engine idle speed. For example, some commercial truck engines idle at a speed of between 600 and 750 rpm.

In some vane pumps used for supplying fluid to a power steering mechanism, all of the vanes may not move radially outward toward the cam ring until the pump reaches an angular velocity that is greater than the vehicle engine's idle speed. For example, in some pumps all of the vanes do not extend radially outwardly toward the cam ring until the rotor of the pump rotates at approximately 900 rpm. Thus, the power steering mechanism in the vehicle having one of these pumps may not be sufficiently responsive until the engine speed is increased to about 900 rpm. It is desirable to increase the responsiveness of the hydraulic power steering mechanism and to provide a pump in which all of the vanes move radially outward toward the cam ring at a pump speed that is well below the vehicle engine's idle speed.

SUMMARY OF THE INVENTION

The present invention relates to an apparatus comprising a pump and a pressure compensating valve. The pump has

an outlet for supplying steering fluid to a power steering mechanism. The pump includes a member (cam ring) having a surface defining a pumping chamber. A rotatable rotor is located in the pumping chamber. The rotor has circumferentially spaced vane-like members defining pumping pockets that expand and contract during rotation of the rotor. The pump has a fluid circuit providing fluid pressure for biasing the vane-like members of the rotor radially toward the surface defining the pumping chamber. The pressure compensating valve controls fluid flow through the outlet and also controls the pressure in the fluid circuit. The pressure compensating valve has an initial condition blocking fluid flow through the outlet at pump start-up to provide fluid pressure in the fluid circuit to bias the vane-like members of the rotor radially toward the surface defining the pumping chamber.

BRIEF DESCRIPTION OF THE DRAWINGS

The foregoing and other features of the present invention will become apparent to those skilled in the art to which the present invention relates upon reading the following description with reference to the accompanying drawings, in which:

FIG. **1** is a schematic illustration of an apparatus constructed in accordance with the present invention;

FIG. **2** is a schematic illustration of a first plate of a vane pump of the apparatus of FIG. **1**;

FIG. **3** is a schematic illustration of a second plate of the vane pump of the apparatus of FIG. **1**;

FIG. **4** is a schematic illustration of a portion of the apparatus constructed in accordance with the present invention; and

FIG. **5** is a graph comparing an operational characteristic of a pump embodying the present invention with a prior art apparatus and a theoretic apparatus.

DETAILED DESCRIPTION OF THE INVENTION

FIG. **1** schematically illustrates an apparatus **10** constructed in accordance with the present invention. The apparatus **10** may be used for supplying hydraulic fluid to a hydraulic motor (not shown), via a control valve (not shown), of a vehicle power steering mechanism.

The apparatus **10** includes a housing **14**, shown schematically in FIG. **1**. The housing **14** includes a single outlet **16** for discharging hydraulic fluid from the apparatus **10** toward the power steering mechanism. The housing **14** also includes a single return port or inlet **18** for returning hydraulic fluid from the power steering mechanism. A fluid reservoir **20**, shown schematically in FIG. **1**, is generally located within the housing **14**. The fluid reservoir **20** supplies fluid to a vane pump **12** of the apparatus **10** and receives fluid returned to the apparatus from the power steering mechanism.

The vane pump **12** of the apparatus **10** illustrated in FIG. **1** is a balanced rotary vane pump. Vane pumps other than balanced rotary vane pump may be utilized with the present invention. The vane pump **12** includes a cam ring **22**. The cam ring **22** is fixed relative to the housing **14** and includes a generally elliptical inner surface **24**. Two inlet ports **26** extend through the cam ring **22** and terminate at the inner surface **24** of the cam ring **22**. Two discharge ports **28** also extend through the cam ring **22** and terminate at the inner surface **24** of the cam ring. Alternatively, the inlet ports **26** and the discharge ports **28** may be located in a plate mounted adjacent cam ring **22** of the pump, such as the plate **52** shown in FIG. **3**.

A rotor **30** is mounted within the cam ring **22** and is rotatable relative to the cam ring **22**. Specifically, the rotor **30** is connected to an input shaft **32**. The engine (not shown) of the vehicle (not shown) drives the input shaft **32**. Thus, as the engine rate increases, the rate of rotation of the input shaft **32** increases and thus, the rotation rate of the rotor **30** increases.

The rotor **30** has a cylindrical outer surface **34** that is coaxial with the input shaft **32**. A plurality of slots or grooves **36** extends into the outer surface **34** of the rotor **30**. FIG. **1** shows ten grooves **36**, for example, extending into the outer surface **34** of the rotor **30**. The number of grooves **36** may be other than ten. The grooves **36** are circumferentially spaced about the outer surface **34** of the rotor **30** and extend along a length of the rotor. Each groove **36** includes a pair of parallel extending side walls **38** and terminates at an inner wall **40**. An imaginary circle (not shown) connecting the inner walls **40** of the grooves **36** is coaxial with the outer surface **34** of the rotor **30** and the input shaft **32**.

Each groove **36** in the rotor **30** carries a vane **42**. Each vane **42** is a generally flat, elongated plate. Each vane **42** is movable relative to the rotor **30** and is sized to slidingly engaging the side walls **38** of the associated groove **36**.

The vanes **42** move radially inwardly, i.e., contract, and radially outwardly, i.e., extend, in the associated grooves **36**. An inner surface **44** of each vane **42** remains within the associated groove **36**, i.e., radially inward on the outer surface **34** of the rotor **30**, during radial movement of the vane **42**. During normal operation of the vane pump **12**, an outer surface **46** of each vane **42** contacts the inner surface **24** of the cam ring **22** and slides along the inner surface of the cam ring during rotation of the rotor **30**. Contact refers to the outer surface **46** of each vane **42** being in close proximity to the inner surface **24** of the cam ring **22** and encompasses a fluid film separating the surfaces.

The vane pump **12** includes a plurality of pumping pockets **48**. Each pumping pocket **48** is defined between adjacent vanes **42** and between the outer surface **34** of the rotor **30** and the inner surface **24** of the cam ring **22**. First and second plates **50** and **52**, respectively, as will be described in detail below with reference to FIGS. **2** and **3**, form two additional surfaces that define the pumping pockets **48**. During rotation of the rotor **30** within the cam ring **22**, the volume of the pumping pockets **48** varies. As the vanes **42** associated with a pumping pocket **48** extend from the rotor **30**, the volume of the pumping pocket **48** increases, i.e., the pumping pocket **48** expands. Contrarily, as the vanes **42** of the pumping pocket **48** contract, the volume of the pumping pocket **48** decreases, i.e., the pumping pocket **48** contracts.

When the input shaft **32** of the vane pump **12** is rotated, the rotor **30** is rotated relative to the cam ring **22**. During normal operation of the vane pump **12**, fluid from the reservoir **20** flows through an inlet port **26** and into a respective pumping pocket **48** of the pump. The fluid flows into the respective pumping pocket **48** during expansion of the respective pumping pocket. As the rotor **30** continues to rotate, the respective pumping pocket **48** begins to contract. When positioned adjacent a discharge port **28**, contraction of the respective pumping pocket **48** results in the fluid being discharged through the discharge port **28**.

The vane pump **12** illustrated in FIG. **1** includes two inlet ports **26** and two discharge ports **28**. Thus, during a single rotation of the rotor **30**, a respective pumping pocket **48** displaces two volumes of fluid from an inlet port **26** to a discharge port **28**. As shown schematically in FIG. **1**, the two discharge ports **28** connect to a discharge fluid chamber **54**. A single fluid passage **56** (FIG. **4**) extends downstream of the discharge fluid chamber **54** for carrying fluid toward the outlet **16** of the apparatus **10**.

The operation of the vane pump **12** described above and referred to as the "normal operation" occurs when all of the vanes **42** of the vane pump **12** are positioned with their outer surfaces **46** in contact with the inner surface **24** of the cam ring **22**. However, when the vane pump **12** is at rest, i.e., the input shaft **32** is not rotating the rotor **30**, some of the vanes **42** of the vane pump **12** may move to a position in which their outer surfaces **46** do not contact the inner surface **24** of the cam ring **22**. For example, assuming that the vane pump **12** of FIG. **1** is mounted in a vehicle so that the ground is located at the bottom of FIG. **1**, gravity may cause the vanes **42** located on an upper side, as viewed in FIG. **1**, to slide downwardly into an associated groove **36** and away from the inner surface **24** of the cam ring **22**. In addition to gravity, vehicle vibrations and other factors may cause various vanes **42** to move away from the inner surface **24** of the cam ring **22**.

When one or more of the vanes **42** of the rotor **30** have moved away from the inner surface **24** of the cam ring **22**, the fluid within one pumping pocket **48** in the pump **12** may flow over a vane **42**, i.e., between the outer surface **46** of the vane **42** and an inner surface **24** of the cam ring **22**, and into an adjacent pumping pocket **48**. Specifically, as the rotor **30** rotates and a pumping pocket **48** begins to contract, only a small amount of fluid may be forced out of the discharge port **28**. As a result, the flow rate of fluid discharged through the discharge ports **28** of the vane pump **12** at a particular pump speed is relatively low when compared to the flow rate at that pump speed when all of the vanes **42** are contacting the inner surface **24** of the cam ring **22**.

As the rotor **30** of the pump **12** begins to rotate from a rest position, i.e., start-up of the pump, centrifugal force begins to act on the vanes **42** to force the vanes into contact with the inner surface **24** of the cam ring **22**. The centrifugal force generally is insufficient to force all of the vanes **42** into contact with the cam ring **22** at a pump speed associated with the vehicle engine's idle speed. Since the centrifugal force is generally insufficient to move all of the vanes **42** into contact the inner surface **24** of the cam ring **22**, other provisions for forcing the vanes against the cam ring **22** are provided, as will be described below.

FIG. **2** illustrates a first plate **50** of the vane pump **12**. The first plate **50** is located adjacent a first side of the rotor **30**. FIG. **3** illustrates a second plate **52** of the vane pump **12**. The second plate **52** is located adjacent a second side of the rotor **30**, opposite the first end. As shown in FIG. **3**, an aperture **58** extends through the second plate **52** for receiving the input shaft **32**. A seal (not shown) may be located in the aperture **58** for preventing fluid leakage between a surface defining the aperture and the input shaft **32**.

With reference to FIG. **2**, an annular groove **60** is formed in a surface of the first plate **50**. The annular groove **60** is coaxial with the input shaft **32** and has an inner diameter and an outer diameter. In an assembled vane pump **12**, the inner diameter of the annular groove **60** aligns with the inner walls **40** of the grooves **36** of the rotor **30**. The rotor **30** is shown by dotted lines in FIG. **2**. The annular groove **60** acts as a fluid conduit, as will be described below.

With reference to FIG. **3**, four arcuate grooves, indicated at **62**, **64**, **66**, and **68**, are formed in a surface of the second plate **52**. The arcuate grooves **62**–**68** have an inner diameter and an outer diameter. In an assembled vane pump **12**, the inner diameter of each arcuate groove **62**–**68** aligns with the inner wall **40** of the grooves **36** of the rotor **30**. The rotor **30** is shown by dotted lines in FIG. **3**. Each of diametrically opposed arcuate grooves **64** and **68** includes a fluid port, shown schematically at **70**. As is also shown schematically in FIG. **3**, arcuate grooves **64** and **68** form a portion of a fluid circuit, indicated generally at **72**.

With reference again to FIG. **1**, a fluid pocket **74** is formed in each groove **36** of the rotor **30**. The inner wall **40** and side walls **38** of the groove **36** and the inner surface **40** of the associated vane **42** define the fluid pocket **74**. As the vane **42** slides radially inwardly and outwardly within the groove **36** of the rotor **30**, the volume of the respective fluid pocket **74** decreases, i.e., contracts, and increases, i.e., expands.

The annular groove **60** on the first plate **50** is in fluid communication with each fluid pocket **74**. As one vane **42** on the rotor **30** moves radially outward, another vane **42** moves radially inward. The radially inward movement of the vane **42** forces fluid out of the contracting fluid pocket **74**. The fluid flows into the annular groove **60** of the first plate **50**. Simultaneously, fluid from the annular groove **60** flows into an expanding fluid pocket **74** moving a vane **42** radially outward.

Additionally, each fluid pocket **74** of the rotor **30** is in fluid communication with at least one arcuate groove **62**–**68** of the second plate **52**. Arcuate grooves **62** and **66** act as fluid conduits similar to the function of annular groove **60**. Arcuate grooves **64** and **68** form portions of the fluid circuit **72** and communicate fluid to the fluid pockets **74** for forcing the vanes **42** radially outwardly toward the cam ring **22**.

As the rotor **30** begins to rotate from a rest position, fluid is discharged into the discharge ports **28** of the vane pump **12**, even when one or more of the vanes **42** have moved radially inwardly out of contact with the cam ring **22**. This discharge fluid increases the fluid pressure within the fluid circuit **72**. As a result, the fluid pressure in arcuate grooves **64** and **68** of the second plate **52** increases. This increased fluid pressure in arcuate grooves **64** and **68** is communicated into the fluid pockets **74** of the rotor **30** adjacent arcuate grooves **64** and **68**. The fluid pressure communicated by arcuate grooves **64** and **68** acts on the inner surfaces **40** of the vanes **42** to force the vanes radially outwardly toward the inner surface **24** of the cam ring **22**. Arcuate grooves **64** and **68** are located in positions adjacent portions of the cam ring where the vanes **42** move radially outwardly or extend. When all of the vanes **42** are positioned radially outward toward the inner surface **24** of the cam ring **22**, normal operation of the vane pump **12**, as described above, begins.

With reference again to FIG. **1**, the fluid discharged into the discharge ports **28** enters the discharge fluid chamber **54**. Fluid passage **56** extends downstream of the discharge fluid chamber **54** for communicating fluid toward the outlet **16** of the apparatus **10**. The discharge fluid chamber **54** and fluid passage **56** also form portions of the fluid circuit **72**.

As shown in FIG. **4**, fluid passage **56** terminates in a spool bore **76** within the housing **14** of the apparatus **10**. The spool bore **76** has a generally cylindrical inner surface **78** and includes a discharge orifice **80** that connects with the outlet **16** of the apparatus **10**.

An orifice plug **82** is located in the discharge orifice **80** of the spool bore **76**. Preferably, the orifice plug is press fit into the discharge orifice **80**. The orifice plug **82** includes a flow control orifice **84** for communicating fluid from the spool bore **76** to the outlet **16**. The outlet **16** of the apparatus **10** is shown in FIG. **4** as including internal threads **86** for receiving a discharge conduit (not shown).

A radially extending passage **88** in the orifice plug **82** connects the flow control orifice **84** to an axially extending passage **90** formed in the housing **14** adjacent the spool bore **76**. Passage **90** connects to a pressure chamber **92**. Pressure chamber **92** connects to the spool bore **76** near an end of the spool bore **76** opposite the outlet **16**.

A pressure compensating valve **94** is disposed in the spool bore **76**. The pressure compensating valve **94** includes a valve spool **96** that is movable axially within the spool bore **76**. The valve spool **96** moves as a function of fluid pressure, as will be described below.

The valve spool **96** includes a generally cylindrical main body portion **98**. A cylindrical outer surface **100** of the main body portion **98** of the valve spool **96** includes a number of annular grooves **102**, four of which are shown in FIG. **4**. Each annular groove **102** is a balancing or anti-stiction groove. The annular grooves **102** act as a labyrinth seal, balance the pressure around the valve spool **96** to center the valve spool in the spool bore **76**, and prevent the valve spool from sticking to a portion of the spool bore. The outer surface **100** of the main body portion **98** of the valve spool **96** also includes an annular bypass groove **104**.

The main body portion **98** of the valve spool **96** also includes a first working surface **106**. The first working surface **106** is generally annular. An elongated member **108** extends axially outwardly from the first working surface **106** of the main body portion **98** of the valve spool **96**. The elongated member **108** is generally cylindrical and has a diameter that is approximately one-third of the diameter of the main body portion **98** of the valve spool **96**. The elongated member **108** terminates opposite the main body portion **98** of the valve spool **96** at an end wall **110**.

The main body portion **98** of the valve spool **96** also includes a second working surface **112** opposite the first working surface **106**. A spring **114** acts between a plug member **116** and the second working surface **112** of the valve spool **96** to bias the valve spool **96** rightward as viewed in FIG. **4**.

When placed in the spool bore **76**, the valve spool **96** defines first and second variable volume fluid chambers **118** and **120**, respectively, in the spool bore. The first fluid chamber **118** is defined between the first working surface **106** of the valve spool **96** and the orifice plug **82**. The second fluid chamber **120** is defined between the second working surface **112** of the valve spool **96** and plug member **116**. The second fluid chamber **120** receives fluid from pressure chamber **92**. Since the second fluid chamber **120** is in fluid communication with the outlet **16** of the apparatus **10**, fluid pressure in the second fluid chamber **120** is generally equal to the fluid pressure at the outlet.

When biased rightward under the force of the spring **114**, the end wall **110** of the elongated member **108** covers the flow control orifice **84** of the orifice plug **82**. Thus, the elongated member **108** prevents fluid flow from the first fluid chamber **118** into the flow control orifice **84** and toward the outlet **16** of the apparatus **10**. Since the elongated member **108** prevents fluid flow through the flow control orifice **84**, fluid pressure in the fluid circuit **72** increases during the initial or start-up rotation of the rotor **30** of the pump **12**.

When the fluid pressure in the first fluid chamber **118**, and thus fluid circuit **72**, exceeds the combined influence of the fluid pressure in the second fluid chamber **120** and the spring **114**, the valve spool **96** moves leftward, as viewed in FIG. **4**. The movement of the valve spool **96** within the spool bore **76** is related to a pressure differential between first fluid chamber **118** and the combined influence of the fluid pressure in the second fluid chamber **120** and the spring **114**. As the valve spool **96** moves leftward, the end wall **110** of the elongated member **108** of the valve spool **96** moves away from the orifice plug **82** and opens fluid flow into the flow control orifice **84**. As the fluid pressure in the first fluid chamber **118** continues to increase, the valve spool **96** continues to move leftward. Contrarily, if the fluid pressure in the first fluid chamber **118** decreases, the combined influence of the fluid pressure in the second fluid chamber **120** and the spring **114** will move the valve spool **96** rightward.

When the pressure within the first fluid chamber **118** increases to a predetermined level, the valve spool **96** of the pressure compensating valve **94** moves leftward a distance sufficient to connect the first fluid chamber **118** with a bypass passage (not shown). Fluid flowing into the bypass passage is conducted away from the outlet **16** of the apparatus **10** and may be conducted to the reservoir **20** of the vane pump **12**.

With reference again to FIG. **4**, the pressure compensating valve **94** also includes a pressure relief valve **122**. A pocket **124** extends into the main body portion **98** of the valve spool **96** from the second working surface **112**. Internal threads **126** are formed in the pocket **124** near an opening into the pocket. A radially extending passage (not shown) connects the pocket **124** to the annular bypass groove **104** for communicating fluid in the pocket to the bypass passage.

The pressure relief valve **122** includes an orifice plate **128** having external threads **130**, a spring **132**, and a movable actuator **134**. The spring **132** biases the actuator **134** away from an inner wall **136** of the pocket **124**. The orifice plate **128** is screwed into the pocket **124** in the valve spool **96**. An orifice **138** extending through the orifice plate **128** receives a nose portion **140** of the actuator **134**.

Fluid within the second fluid chamber **120** flows through the orifice **138** of the orifice plate **128** of the pressure relief valve **122** and acts on the nose portion **140** of the actuator **134**. The nose portion **140** of the actuator **134** prevents fluid flow from the orifice **138** of the orifice plate **128** into the pocket **124** when the biasing pressure of the spring **132** is greater than a fluid pressure in second fluid chamber **120**. When the fluid pressure in the second fluid chamber **120** increases above the biasing pressure of the spring **132**, the actuator **134** is moved rightward, as viewed in FIG. **4**, and fluid flows into the pocket **124**. Fluid flowing into the pocket **124** passes through the radial passage (not shown), into the annular bypass groove **104**, and then into the bypass passage (not shown).

When fluid within the first fluid chamber **118** is prevented from flowing into the flow control orifice **84**, fluid pressure in the first fluid chamber increases. As a result, fluid pressure in fluid circuit **79** increases.

As stated above, arcuate grooves **64** and **68** in the second plate **52** of the vane pump **12** form a portion of the fluid circuit **72**. As a result, fluid pressure in arcuate grooves **64** and **68** increases as fluid pressure in fluid circuit **72** increases. The fluid in the arcuate grooves **64** and **68** is communicated into the fluid pockets **74** of the rotor **30** and acts on the inner surfaces **44** of the vanes **42** to force the vanes radially outwardly toward the inner surface **24** of the cam ring **22**. By increasing the fluid pressure in fluid circuit **72**, the fluid pressure in the fluid pockets **74** of the rotor **30** increases. As a result, all of the vanes **42** of the pump **12** are forced to extend radially outward and contact the inner surface **24** of the cam ring **22** at a lower vane pump speed.

FIG. **5** is a graph comparing an operational characteristic of an apparatus constructed in accordance with the present invention with a prior art apparatus and a theoretic apparatus. FIG. **5** illustrates the flow from the outlet of each apparatus in relation to the pump speed of the pump of each apparatus.

The line labeled A in FIG. **5** illustrates the flow from the outlet of a theoretic apparatus as a function of pump speed. In the theoretic apparatus, all of the vanes of the pump are instantaneously extended radially outwardly toward the cam ring as rotation of the rotor of the pump begins. As line A illustrates, the flow from the theoretic apparatus increases proportionally with pump speed until a designed flow rate, indicated at X, is achieved. When the designed flow rate X is achieved, additional flow produced by the pump of the theoretic apparatus is bypassed so that a constant flow is output from the theoretic apparatus. Alternatively, the outlet flow from the theoretic apparatus may be decreased as pump speed increases, as is known in the art.

The line labeled B in FIG. **5** is an apparatus **10** constructed in accordance with the present invention. As illustrated by line B, upon initial rotation of the rotor **30**, i.e., start-up of the pump, no flow is discharged from the outlet **16** of the apparatus **10**. At the point on line B labeled Y, all of the vanes **42** of the pump **12** have moved radially outwardly toward the cam ring **22** and the fluid pressure in the first fluid chamber **118** is sufficient to move the valve spool **96** to open flow through the flow control orifice **84** to the outlet **16** of the apparatus **10**. Once all of the vanes **42** have moved radially outward toward the cam ring **22** and the valve spool **96** opens the flow control orifice **84**, the outlet flow from the apparatus **10** follows the flow of the theoretic apparatus illustrated by line A.

The line labeled C in FIG. **5** is an apparatus of the prior art. As illustrated by line C, upon start-up of the pump, very little flow is discharged from the outlet of the prior art apparatus. In fact, the flow rate is so low that it is illustrated as zero in FIG. **5**. At the point on line C labeled Z, all of the vanes of the pump of the prior art apparatus have moved radially outwardly toward the cam ring. Once all of the vanes have moved radially outward toward the cam ring, the apparatus of the prior art follows the flow of the theoretic apparatus illustrated by line A.

As is clear from the graph of FIG. **5**, the apparatus **10** constructed in accordance with the present invention, more closely emulates the theoretic apparatus. The vanes **42** of the pump **12** of the apparatus **10** move radially outwardly toward the cam ring **22** at a much lower pump speed than the prior art apparatus. The spacing between point Y and point Z in FIG. **5** illustrates this difference. As a result, the apparatus **10** is more likely to provide the flow necessary to operate a power steering mechanism when the vehicle is operating at its engine's idle speed.

From the above description of the invention, those skilled in the art will perceive improvements, changes and modifications. Such improvements, changes and modifications within the skill of the art are intended to be covered by the appended claims.

Having described the invention, the following is claimed:

1. Apparatus comprising:

a pump having an outlet for supplying steering fluid to a power steering mechanism, said pump including a member having a surface defining a pumping chamber, a rotatable rotor in said pumping chamber, said rotor having circumferentially spaced vane-like members defining fluid pockets which expand and contract during rotation of said rotor;

said pump having a fluid circuit providing fluid pressure to said fluid pockets for biasing said vane-like members of said rotor radially toward said surface; and

a pressure compensating valve for controlling fluid flow through said outlet and for controlling the fluid pressure in said fluid circuit, said pressure compensating valve having an initial condition blocking fluid flow through said outlet at pump start-up to provide fluid pressure in said fluid circuit to bias said vane-like members of said rotor radially toward said surface.

2. Apparatus as defined in claim **1** wherein said pressure compensating valve is actuated from the initial condition to a condition enabling fluid flow from said outlet in response to a pressure increase in said fluid circuit acting on said pressure compensating valve.

3. Apparatus as defined in claim **1** wherein said pump includes a plate located adjacent a side of said rotor, said plate including at least one groove, said at least one groove forming a portion of said fluid circuit and being in fluid communication with a plurality of said fluid pockets.

4. Apparatus as defined in claim **3** wherein said at least one groove is an annular groove that is in fluid communication with all of said fluid pockets.

5. Apparatus as defined in claim **3** wherein said at least one groove includes an arcuate groove having a port through which fluid pressure is communicated.

6. Apparatus as defined in claim **1** wherein said pressure compensating valve includes a valve spool that is movable within a spool bore, a spring urging said valve spool against an orifice for blocking fluid flow through said outlet.

7. Apparatus as defined in claim **6** wherein said valve spool divides said spool bore into first and second fluid chambers, said first fluid chamber forming a portion of said fluid circuit, fluid pressure in said first fluid chamber acting on said valve spool to compress said spring and move said valve spool away from said orifice for enabling fluid flow through said outlet.

8. Apparatus as defined in claim **7** wherein fluid pressure in said second fluid chamber acts on said valve spool to aid said spring in urging said valve spool against said orifice for blocking fluid flow through said outlet.

9. Apparatus as defined in claim **8** wherein said second fluid chamber is in fluid communication with said outlet, downstream of said orifice.

10. Apparatus as defined in claim **8** wherein said valve spool includes a pressure relief valve, said pressure relief valve being actuatable in response to a predetermined pressure to direct fluid away from said second fluid chamber and thereby, reduce fluid pressure in said second fluid chamber.

11. Apparatus as defined in claim **1** wherein said pressure compensating valve includes a valve spool that is movable within a cylindrical spool bore, said valve spool including a cylindrical body portion having a plurality of annular grooves which act to center said valve spool within said spool bore.

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